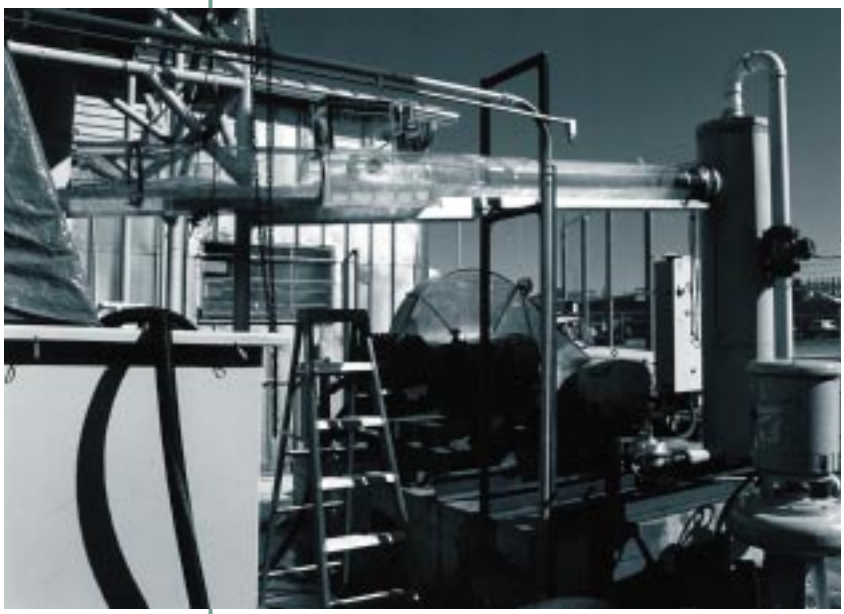
Drilling

Geothermal energy resources consist of reservoirs of hot water or steam lying beneath the Earth's surface. To be used either in generating electricity or in producing heat, these reservoirs must be found and tapped by drilling through the Earth's surface. The U.S. Department of Energy, in partnership with the geothermal industry, is perfecting drilling technologies and lowering geothermal development costs.

The Key to Economic Geothermal Development

Drilling is used to locate geothermal resources and to collect data to define the nature of the geothermal reservoir. The drill holes are then used as conduits for pumping the geothermal fluid to the surface to perform work and for returning the fluids to the reservoir. Geothermal drilling presents unique challenges to drilling technology because of especially high temperatures and hard rock formations.

To drill a geothermal well, a drill bit is mounted on the end of a long metal tube called a drill string, which is rapidly rotated to turn the drill bit. New lengths of metal tubing are added to the top of the drill string as the drill goes deeper into the ground.



Sandia National Laboratories/PIX04885

The rolling float meter (a laboratory prototype pictured) can detect very small fluid losses that correlate with the location of fractures in the geothermal wellbore.

Sandia National Laboratories/PIX05933

Polycrystalline diamond compact (PDC) drill bits, such as this one developed at Sandia National Laboratories, account for more than one-third of the total footage drilled worldwide. Work is continuing to improve performance in hard rock geothermal drilling.

To cool and lubricate the drill bit and carry away the bits of rock cut by it, a viscous fluid called drilling mud is pumped down the tube. The mud comes out through holes in the drill bit and flows back up the well in the space between the well wall and drill string.

Drilling costs can represent as much as one-third of the total cost of a geothermal energy installation because of the hard rock, high temperatures, and corrosive fluids of a geothermal environment, plus problems with lost circulation—the loss of drilling mud into rock fractures. U.S. Department of Energy (DOE) research focuses on those parts of the drilling process that have the potential for substantially reducing costs, including stronger drill bits, detection and treatment of lost circulation zones, lower-cost "slimhole" drilling and data recovery, and improved downhole measurements.

Research Supported by the U.S. Department of Energy

Drilling costs are largely determined by how quickly the drill bit can penetrate through the hard, abrasive, and fractured rocks of a geothermal location, and how long it can last before the drill string needs to be taken out of the hole and the bit replaced. A doubling of both penetration rate and bit life would result in an average 15% reduction in drilling costs.

Researchers are working to improve the cutter design of the typical drill bit by analyzing thermal and mechanical stresses and performing extensive wear tests on a variety of advanced technology bit materials. The program is moving toward the goal of developing optimal drill-bit cutter configurations and materials to increase penetration rates in hot, hard rock.

Lost Circulation Equates to Lost Productivity

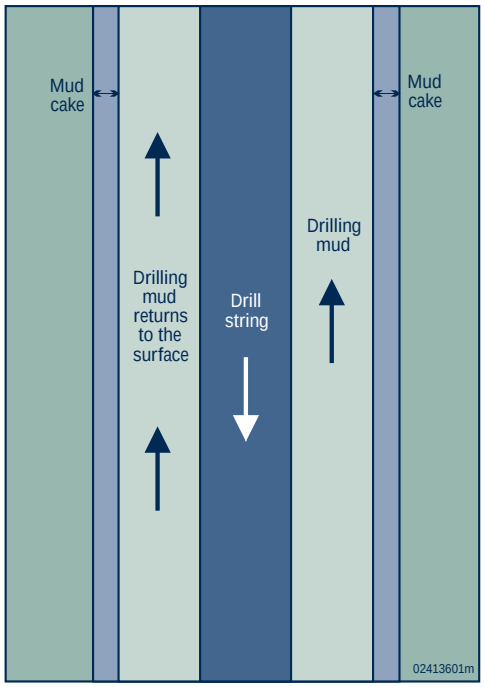
The program is also working to detect areas where drilling mud is lost to the process. Losing drilling mud into the surrounding rock can add 20%–30% to the total cost of a well, primarily because of lost

drilling time and the risk of severe problems such as borehole instability or stuck drill strings. Researchers have developed a rolling float meter and have used it together with an advanced acoustic doppler flowmeter to detect and quantify lost circulation. This technology is currently being transferred to industry.

Work is also being done to integrate the meters into an expert system for diagnosing drilling problems. DOE is also supporting field testing of new high temperature cements for reducing the cost of plugging lost circulation zones.

Slimhole Drilling May Lower Costs

The use of smaller-than-standard-diameter drilling bits and pipe, referred to as "slimhole" drilling, has been demonstrated to reduce oil and gas exploration costs by 25%–75%. DOE-supported researchers are investigating if slimhole drilling can provide sufficient data to characterize a geothermal reservoir and are evaluating slimhole drilling costs. Initial results are very encouraging and are being widely disseminated to encourage slimhole exploration of geothermal resources.



Drilling mud brings rock chips back to the surface and cools the drill bit. DOE is field testing new high temperature cements for reducing the cost of plugging lost circulation zones.

Improved Instruments for Cost-Saving Data

To function effectively in the geothermal environment, instrumentation used in the petroleum industry for gathering drill-hole data must be adapted for slimhole drilling and high-temperature conditions. Downhole measurement tools that meet the temperature and size requirements of the geothermal industry have been developed, including a promising new self-contained, battery-powered, memory-storage system. These tools are available for application or are in the late stages of testing; thus, they are being moved into the field through technology transfer with industry.

The Future

Through its work with industry, the DOE geothermal drilling program is perfecting drilling technologies, concentrating its efforts on those areas that promise the largest cost reductions. Reducing drilling costs will substantially cut the costs of geothermal development, thus helping the geothermal industry to expand its markets.

Geothermal Drilling Organization

The Geothermal Drilling Organization (GDO) was formed as a mechanism for the geothermal industry to work cooperatively with DOE on cost-shared projects for the development of drilling technology. Industry sets research priorities and shares more than 50% of the cost. DOE provides project management expertise and access to research facilities and staff. The GDO and its associated group, the Geothermal Technology Organization, frequently provide the test sites where new technology and methods are field-proven.

For more information on geothermal technologies, call the Office of Geothermal Technologies: (202) 586-5340

or visit the Web site:
http://www.eren.doe.gov/geothermal

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